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ENVIRONMENTAL ASPECTS OF PIPELINE ROUTE SELECTION

By Francis J. Stastny¹, F. ASCE

INTRODUCTION

In the last few years there has been a tremendous increase in "environmental awareness" on the part of the general public. This awareness has at different times and in different places manifested itself in the formation of various conservation and ecology groups adamantly opposed to any intrusion into "their" environment. Major projects such as the Alyeska Pipeline, several nuclear power plants, and oil refineries have been halted, at least temporarily, by those who question the feasibility of the project from an environmental aspect. This kind of delay is taking place in spite of a threatening energy crisis.

The interactions among governmental regulatory agencies, corporations requiring land corridors for their transportation facilities, and the public, relative to their awareness of, and posture toward, the environment have not as yet evolved into a stable relationship. Strong opposition to some projects by environmental protectionist groups has caused lengthy public hearings and, on occasion, legal action. This type of intervention has increased the time required for obtaining regulatory approval than was being experienced a few short years ago. It is evident, therefore, that planning for new pipelines, and similar projects requiring land

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corridors, should include provisions for pretesting public and regulatory agency acceptance of the environmental aspects of the project in order to minimize the opposition.

ENVIRONMENTAL POLICY PROCESSES

Pressure exerted on legislatures by groups of environmentalists has resulted in the enactment of such legislation to "protect" the environment as the National Environmental Policy Act (NEPA) of 1969 by Congress and additional Environmental Acts by State Legislatures.

Although the provisions of these Acts have caused new problems for pipeline companies requiring corridors for their facilities, the Acts have exerted a positive influence on route selection techniques. No force in recent years has provided greater impetus for the development of new techniques of environmental analysis and planning than Section 102 of NEPA. There are several provisions in this Section which highlight the need to develop new methods and procedures that integrate the natural and social sciences to insure a systematic approach to planning and decision-making in order to minimize the impact on man's environment. Specifically, NEPA states:

" . . . to the fullest extent possible: (1) the policies, regulations, and public laws of the United States shall be interpreted and administered in accordance with the policies set forth in this Act, and (2) all agencies of the Federal Government shall -

(A) utilize a systematic, interdisciplinary approach

which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision-making which may have an impact on man's environment.

- (B) identify and develop methods and procedures, in consultation with the Council on Environmental Quality established by title II of this Act, which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decision-making along with economic and technical considerations;
- (C) include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on -
 - (1) the environmental impact of the proposed action,
 - (2) any adverse environmental effects which cannot be avoided should the proposal be implemented,
 - (3) the alternatives to the proposed action,
 - (4) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

- (5) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented . . .
- (D) study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources;
. . .
- (E) initiate and utilize ecological information in the planning and development of resource-oriented projects; . . ."

Although NEPA states the requirements for a multidisciplinary approach to decision-making, it has become apparent that the form and content of such an endeavor is important. The lack of precise knowledge about some of the many important elements of the environment and the need to account for divergent social value systems dictate the necessity for careful consideration of these factors in the decision process. Therefore, efforts have been concentrated on developing various decision models which recognize these inadequacies and can manipulate the available data to meet the environmental requirements.

Some of the regulatory agencies which require that an environmental report be submitted as part of the supporting data for an application for a certificate to construct a new pipeline facility include the Federal Power Commission (FPC) and various State agencies, such as Public Service Commissions and Natural

Resource Department. The usual procedure is for these agencies to take the information contained in the environmental reports and prepare environmental impact statements. Impact statements are then circulated among other Federal or State agencies (depending upon whether Federal or State regulatory agencies have jurisdiction) for review, comments and/or objections to the proposed pipeline. The approval of a project depends partially upon the analysis of the comments and objections, if any, to the environmental impact statement.

Just what is meant by the "environment" in relation to pipelines and related facilities?

The "environment" pertains to such things as:

1. Water

- a. Rivers and lakes - scenic areas, recreational areas.
- b. Marshlands - aquatic habitats.

2. Land

- a. Physiography - soils, flora, fauna.
- b. Land use - urbanization, residential, commercial and industrial development.
- c. Agriculture - cultivation, pasture and forests.

Both these and other environmental elements are comprehensively analyzed and evaluated in an environmental impact report. Some of these other environmental elements include population, economic structure, unavoidable adverse effects and alternate methods of transportation.

A PIPELINE CORRIDOR SELECTION MODEL

The preparation of an environmental report can be simplified and well documented if use is made of a corridor delineation-decision model. One such model has been developed to provide a comprehensive and systematic approach to, and to provide detailed documentation for, selecting a pipeline corridor.

This corridor selection model assumes that more effective planning will result from more precise and efficient inventory and analysis methods than are currently being used. The other basic assumptions are:

1. That any geographic area can be thought of as being composed of a number of cells upon which certain natural and cultural conditions and/or activities prevail; and,
2. That the suitability of a cell for the location of a pipeline facility can be represented as an evaluation function of the general form

$$S_{ij} = f (X_i, Y_j)$$

where:

S_{ij} - the suitability of cell i for pipeline facility configuration j

X_i - the set of variables which describe the natural and cultural conditions and/or activities prevailing in cell i

- Y_j - the set of variables which describe the physical characteristics of the pipeline facility configuration j
- f - the evaluation function(s) which relates the values of the variables describing X and Y to S

These assumptions imply several basic tasks which must be performed. These include corridor delineation, environmental inventory and environmental analysis. Although these tasks are best discussed separately, they are all mutually interdependent and should not be considered as isolated variables.

CORRIDOR DELINEATION

The study area should include all the area in which the particular pipeline could be feasibly located. In general, the larger the area considered the greater the legitimacy of the effort. However, time and economic constraints are generally the factors which establish the geographic boundaries for the study area. Thus, a pragmatic approach which considers these factors as well as the data cell size, number of inventory variables and data sources is usually best. Current methods are almost entirely based on a uniform square cellular grid system.

Square cells offer the advantages of constant size (area), shape, orientation and number of neighboring cells all of which greatly facilitate analysis. The critical decision with regard to the use of cells is one of size. The smaller the

cell size the better is a good general guideline, but this must be balanced with scale of the source data, project economics and the complexity of the study area.

A geographic reference system is necessary to delineate possible pipeline corridors. Artificial systems can be easily developed but it is generally best to use some true geographic coordinate system. Of these the Universal Transverse Mercator system is commonly employed.

ENVIRONMENTAL INVENTORY

A comprehensive environmental inventory of both the existing and proposed natural and cultural conditions must be conducted for the study area selected. The exact content of this effort is determined by a number of factors of which the more important include:

1. Types and sources of existing data;
2. Decision model evaluation functions; and
3. Project economics.

A general view of the world as composed of two interdependent systems, natural and cultural, provides the framework for the conduct of this effort. Since data collection is a time consuming and expensive task, heavy reliance is placed on the use of existing data and remote sensing techniques. Costs, therefore, can be held to a minimum.

Table 1 illustrates an environmental inventory which would be used in selecting a pipeline corridor. This inventory

includes the inventory variable, the data source, and the method of measurement. Data is collected on the basis of square cells and is recorded in as objective a fashion as possible to maintain a maximum flexibility in data utilization.

Data and information for corridor optimization is obtained from many sources, such as:

1. Aerial photographs obtained from the U.S. Department of Agriculture;
2. U.S.G.S. Quadrangle Maps;
3. Population and land use data from local and regional agencies;
4. Zoning Ordinance of Local Governments;
5. Average 24-hour traffic counts for major highways from State Highway Departments;
6. County Plat Books;
7. Land Ownership County Maps for State and Federal lands;
8. Vegetation cover maps;
9. Geology and ground water maps; and
10. Pipeline construction specifications.

The necessary data and information is obtained from Federal, State and local agencies such as U.S. Department of Agriculture, Soil Conservation Service; State Department of Natural Resources (or equivalent); Regional Planning Commissions; and Local Zoning Boards.

TABLE 1

ENVIRONMENTAL INVENTORY

Inventory Variables	Data Source	Method of Measurement
Vegetation:		
Forest/Woodland	Aerial Photos	Percent of cell coverage
Brushland	" "	Percent of cell coverage
Topography:		
Centroid Elevation	USGS Maps	Elevation in feet at center of cell
High Elevation	" "	Elevation in feet of highest point in cell
Low Elevation	" "	Elevation in feet of lowest point in cell
Hydrology:		
Intermittent Stream	Aerial Photos/USGS Maps	Number occurring in cell
Continuous Stream	" "	" "
River	" "	" "
Wetland	" "	Percent of cell coverage

Inventory Variables		Data Source	Method of Measurement
Hydrology: (con't)			
Pond/Small Lake		Aerial Photos/USGS Maps	Percent of cell coverage
Inland Lake		" "	" "
Reservoir		" "	" "
Existing Land Use:			
Agriculture-Pasture/Inactive		Aerial Photos	Percent of cell coverage
Agriculture-Cultivated Crops		" "	" "
Agriculture-Orchards/Tree Farm		" "	" "
Residential-Rural Non-Farm		" "	" "
Residential-Suburban		" "	" "
Residential-Urban		" "	" "
Commercial		" "	" "
Industrial-Plants/Facilities		" "	" "
Recreation/Conservation		" "	" "
Urban/Suburban Vacant		" "	" "
Existing Communications:			
Roadway-Local		Aerial Photos/USGS Maps	Number occurring in cell
Roadway-County		" "	" "

Inventory Variables		Data Source	Method of Measurement
Existing Communications: (con't)			
Roadway-State		Aerial Photos/USGS Maps	Number occurring in cell
Roadway-Federal & Interstate		"	"
Railroads		"	"
Pipelines/Aqueducts		"	"
Power Transmission Lines		"	"
Airports		"	Percent of cell coverage
Proposed Land Use:			
Agricultural		County Master Plans	Percent of cell coverage
Residential		"	"
Commercial		"	"
Industrial		"	"
Recreation/Conservation		"	"
Proposed Communications:			
Roadway		County Master Plans	Number proposed in cell
Railway/Rapid Transit		"	"
Pipelines/Aqueducts		"	"
Airport		"	"

Inventory Variables	Data Source	Method of Measurement
Cultural Features:		
Historic/Archeological Sites	Historical Societies	Number occurring in cell
Cemeteries	Aerial Photos/USGS Maps	Percent of cell coverage
Unique Ecological Features	All Available Sources	" " "

This data is transcribed on the cellular grid system. Thus, continuous analog data is transformed into discrete digital information for computer processing. The environmental factors affecting route locations through each cell are evaluated on the basis of eight numerically scaled criteria including:

1. Percent of vegetation;
2. Topography;
3. Water and wetland;
4. Transportation;
5. Population density;
6. Land use restraints (landing strips, radio towers,
historic sites, etc.);
7. Future land use; and,
8. Soils or agricultural capabilities.

All criteria are assigned a value scale ranging from 0 to 10. Zero represents no impact and 10 signifies a high degree of impact.

ENVIRONMENTAL ANALYSIS

The key task in the development of the decision model is the determination of what criteria are to be used to judge the suitability of a cell for the location of a pipeline. Although a single evaluation function can be defined in corridor selection, it is best to identify several which individually isolate various dimensions of the total problem of selecting an environmentally compatible corridor. In this manner, alternative policies which differentially emphasize various criteria can be considered.

Computer output runs for each environmental factor, such as water; vegetation; land use constraints; population density; land ownership concentration; and future land use, provide a cell by cell map of the study area shaded by overprinting to visually correspond with the degree of impact associated with each factor. Areas rated 10 appear opaque with lesser values becoming progressively lighter. An optimum route is selected for each variable.

A weighted composite is then produced which represents the sum total of the environmental variables scored relative to one another. The optimum route selected for each variable is then overlaid on a composite print-out and a corridor of least resistance, or lowest sum of impact values, is selected. Final corridor selection is made after a field engineering reconnaissance is made and the findings incorporated into the study.

The weightings given to one environmental factor versus another are reflective of explicit strategies or policies for selecting a pipeline corridor and are based on the environmental guidelines published by the Federal Power Commission, the U.S. Departments of Interior and Agriculture, and other important considerations. The six strategies are:

1. Minimize Damage to Natural Systems

The construction procedures and the permanent installation of the pipeline should have a minimal effect on the ecology of the region traversed.

2. Minimize Conflict with Existing Land Uses

The permanent installation of the pipeline should avoid areas of population concentration and intense activity.

3. Minimize Conflict with Proposed Land Uses

Location of the pipeline should consider proposed future land uses and avoid those areas of future population concentration and intense activity.

4. Minimize Conflict with Culturally Significant Features

The pipeline should avoid areas of existing and predictable cultural and historical significance.

5. Minimize Total Financial Investment

For the utility, the costs of land acquisition and pipeline construction should be minimized.

6. Maximize Potential for Right-of-Way Sharing

Existing and proposed rights-of-way compatible with the location of a pipeline should be utilized.

The weighting of each inventory variable relevant to each strategy is a subjective process and is done by a multidisciplinary team to reflect the relative suitability of each cell for the location of a pipeline. This multidisciplinary team includes pipeline engineers, landscape architects, community planners, geologists, biologists, naturalists, foresters and others as each project may require.

The subjectivity of placing "weights" on each variable may appear at first glance to be a weakness of the analysis

because the "weight" is subject to challenge. However, this really is a strength because the effect of a different "weight" of a variable on the corridor selection can be measured by merely changing the "weight" assigned to that variable and comparing the results to that previously obtained.

One of the benefits of the corridor selection program is its ability to provide high level documentation and to cast analytic assumptions into explicit terms. This technique has a distinct advantage in that the appropriateness of each step in the planning process can be graphically demonstrated. Considering the growing impetus for public hearings, it is particularly important that documentation be available to show the comprehensive research and planning, including the consideration of alternate route possibilities, which was used in the preparation of the environmental report.

Another benefit of the corridor selection program is its flexibility. Any number of parameters may be accommodated to (1) examine and evaluate potential areas of environmental conflict, and (2) provide delineation and definition of existing and planned conditions.

SUMMARY

The preparation of an environmental impact report is simplified when the corridor selection model is used to optimize the pipeline route because:

1. The trouble areas are more readily identifiable;
2. Several alternate routes can be investigated with

- a minimal incremental study cost;
3. Trade-offs between capitalization costs and adverse environmental affects can be identified;
and
4. Credible documentation is available.

The necessity of documenting not only the technical and economic feasibility aspects of a pipeline project, but also the pipeline's compatibility with man's environment, is here to stay. The corridor delineation-decision model provides management and regulatory officials with factual information necessary for decision-making. The environmental impact report provides a well-documented, comprehensive and logical analysis of the effect on the environment, if any, which may occur as a result of the proposed pipeline project.